DISTRIBUTION AND CHARACTERISTICS OF SPAWNING ROUND WHITEFISH IN LAKE ONTARIO, 1976-1981

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DISTRIBUTION AND CHARACTERISTICS OF SPAWNING ROUND WHITEFISH IN LAKE ONTARIO, 1976-1981

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ABSTRACT

Haymes, Gerard T., and Dianne P. Kolenosky. 1984. Distribution and characteristics of spawning round whitefish in Lake Ontario, 1976-1981. Ont. Fish. Tech. Rep. Ser. No. 14: ii & 9p.

Round whitefish (*Prosopium cylindraceum*) were gill netted during November and December, from 1976 through 1981, at locations along the north shore of Lake Ontario, as part of a program to assess the potential impact of current and future electrical generating facilities. Most round whitefish collected were in spawning condition and ranged in age from 2 to 8 years. Male round whitefish mature earlier than most females. Spawning occurred in the first 2 to 3 weeks of December, when water temperatures were less than 3°C. Gill net catches in November and December and substrate conditions suggest that round whitefish spawn in 5 to 10 m of water, along the north shore of Lake Ontario from Pickering to Port Hope, with an apparent preference for headlands. Comparison of round whitefish growth curves from various lakes indicates that growth is inversely related to latitude.

Keywords: round whitefish, spawning, distribution, characteristics, Lake Ontario

DISTRIBUTION AND CHARACTERISTICS OF SPAWNING ROUND WHITEFISH IN LAKE ONTARIO, 1976-1981

INTRODUCTION

Published information on round whitefish (*Prosopium cylindraceum*) is relatively scarce. Three studies in the Upper Great Lakes (Bailey 1963, Mraz 1964, Armstrong et al 1977), one on Great Bear Lake (Kennedy 1949) and one on Newfound Lake, New Hampshire (Normandeau 1969) are the only studies found which have presented basic life history information. Characteristics of the Lake Ontario population, which approaches the southern limit of this species' range, have never been documented.

Significant harvests of round whitefish have been reported for Lakes Superior and Huron, but not for Lake Ontario in the past 30 years. Commercial fishing in the central and western basins of Lake Ontario has been reduced since the collapse of the lake whitefish (*Coregonus clupeaformis*) population in the late 1920's (Christie 1973). Although round whitefish has not been an important component of the limited fishery, one fisherman reported a harvest of 1180 kg from Lake Ontario in 1975 (Ridgley 1976). From 1976 to 1981, less than 450 kg were taken annually (Ridgley 1983; OMNR unplubished data).

Discharge of heated water from electrical generating stations into the nearshore zone of Lake Ontario has potential implications for the lake's aquatic biota. Due to the relation between water density and temperature, thermal plumes tend to spread across the surface of the lake during the summer. During the winter, when ambient water temperatures are less than 4°C, however, thermal plumes sink to the bottom as their temperature decreases to 4°C. This can result in intermittent elevation of nearshore bottom water temperatures. Griffiths' (1979, 1980) laboratory experiments demonstrated that unstable thermal regimes during egg incubation affect survival and time of hatch of lake whitefish, round whitefish and splake (*Salvelinus fontinalis* x *S. namaycush*). Of these species, round whitefish was found to be the most sensitive to elevated temperature during incubation. The temperature regimes used by Griffiths were base temperatures of 1.7 to 10.0°C, with periodic fluctuations of from -9° to +9°C from the base temperature (maximum and minimum temperature of 10°C and 1°C). Due to their thermal sensitivity and their relative abundance along the north shore of Lake Ontario, round whitefish were selected as an indicator of the potential impact of a sinking thermal plume on fall-spawning fish species.

As part of a program to assess the potential impact of the existing Pickering 'A' Generating Station (GS) and the future or proposed generating stations of Pickering 'B', Darlington and Wesleyville, studies of fall-spawning round whitefish were conducted from 1976 through 1981 as a joint undertaking of Ontario Hydro and the Ontario Ministry of Natural Resources.

This paper documents the distribution of spawning round whitefish along a portion of the north shore of Lake Ontario, and describes the species' biological characteristics.

METHODS

From 1976 to 1981, fish were collected by gill net, during November and December, at 22 locations along the north shore of Lake Ontario from Pickering to Port Hope (Figure 1). The number of sets, location, and depth of sets varied among years (Table 1). Experimental gill nets generally consisting of 8 panels with stretched mesh sizes of 3.8 cm (1.5 inches) to 12.7 cm (5.0 inches) in increments of 1.3 cm (0.5 inch) (1976 and 1977 excluded, see Table 1) were set perpendicular to shore. Since the 3.8 cm (1.5 inch) and 5.1 cm (2.0 inch) meshes collected few whitefish, they were not included in the calculation of catch per unit effort (number per 22.9 m (25 yds.) of gill net set for 24 hours). The gill net panels were constructed of multifilament white nylon. Those set by Ontario Hydro (excepting 1976 and 1977, see Table 1) were generally 15.3 m (50 ft.) long; those set by the Ontario Ministry of Natural Resources, 45.8 m (50 yds.). Generally, nets were lifted after 24 hours but due to poor weather on some sampling dates, nets were in the water as long as 144 hours. For purposes of calculation, the nets set for more than 24 hours were not corrected for the duration of the set as they were generally fouled and did not catch substantially more fish than a typical 24-hour set.

Fish were sampled for sexual maturity, fork length and weight. Scales, for age and growth measurements, were taken from the left side, beneath the anterior margin of the dorsal fin above the lateral line. The number of annuli on scales was determined and, for scales collected at Darlington in 1977 and Pickering in 1980, the distance from the focus of the scale to each annulus, and to the edge of the scale, along a line from the focus to the lower posterior corner of the scale, was measured. Total lengths were measured on a sample of 90 fish caught at Pickering, in 1979, and Darlington, in 1980, to permit extrapolation and comparison with other published information. The derived equation ($r = 1.0$) was:

$$\text{total length(mm)} = 1.07\ \text{fork length(mm)} + 5.19.$$

To compare the relative growth of various year-classes caught at Darlington in 1977 and Pickering in 1980, back-calculated growth curves were prepared based on scale and observed fork length measurements. Based on our sample, the

regression equation was calculated to be:

$$\ln \text{ fork length(mm)} = 0.757 \ln \text{ scale radius(mm)} + 4.90 \quad (r = 0.861, 148 \text{ df})$$

Back-calculated fork lengths were subsequently converted to total length.

RESULTS AND DISCUSSION

DISTRIBUTION

During these studies, 2776 fish of 21 species were collected (Table 2). White sucker (*Catastomus commersoni*, 40%) and round whitefish (24%) were the most frequently caught fish. In addition to round whitefish, other fall-spawning salmonids: brown (*Salmo trutta*), rainbow (*S. gairdneri*) and lake trout (*Salvelinus namaycush*), coho (*Oncorhynchus kisutch*) and chinook salmon (*O. tshawytscha*) and lake whitefish, combined for 10% of the catch. Round whitefish was the first, second, or third most abundant species in each year.

The catch of round whitefish (Table 3) per 22.9 m (25 yds.) of gill net (6.3-12.7 cm mesh) averaged 0.6 over the six years of study, with highest catches in 1977 (1.7) and 1981 (2.1). The latter value was influenced by a large catch of 68 round whitefish (representing 83% of those caught in that year) in one lift. Although variation among years at those locations sampled in more than one year was relatively high, it would appear that largest concentrations were in the area of Thickson Point, Raby Head and Bond Head, suggesting that spawning round whitefish tend to congregate at headlands rather than featureless shoreline. There did not appear to be an attraction to the thermal discharge of Pickering GS 'A' during the netting period, mid-November to mid-December.

Higher catches were recorded in nets set with the inshore end in shallow (3 m) rather than deep (10 or 15 m) water in 1977 and 1979 (Table 4). In 1978, catches were relatively low in both the inshore (5 m) and offshore (15 m) nets. The nets set at an intermediate depth (7 m) in 1981 had the highest catch per unit effort. A comparison of short (15.3 m panels) and long (45.8 m panels) nets set on alternate days at Whitby West and Thickson Point in 1980 revealed that the longer nets, which fished slightly deeper despite the inshore end being set at the same depth, caught more ($0.1 < p < 0.05$, t-test, 14 df) round whitefish on a catch per unit effort basis (0.8 per net) than did the short nets (0.2 per net). These findings suggest that round whitefish in Lake Ontario spawn at moderate depths of about 5 to 10 m. This depth range compares favourably with depths reported by Scott and Crossman (1973) for Lake Superior (6 m), and by Koelz (1929) for Lakes Huron and Superior (3-14 m). Shallower depths have been reported in other lakes: less than 1 m in Newfound Lake (Normandeau 1969), and less than 2.5 m in Aishihik Lake, Yukon (Bryan and Kato 1975).

Round whitefish have been reported to spawn over gravel and rubble (Normandeau 1969), primarily gravel (Bryan and Kato 1975) and rubble and rock (Koelz 1929). The substrate in our study area is primarily glacial sediment overlain with sand and silt in bay areas and the mouths of rivers and streams (Rukavina 1969, 1970 and 1976). This glacial sediment is variable, ranging from clay to boulder, suggesting that suitable spawning substrate (gravel, rubble) is interspersed through most of the study area. Finer scale studies of substrate in the area of Pickering GS and the future Darlington GS confirmed the presence of isolated gravel beds within small to medium sized rocky substrates (Dunford 1980, Kwik 1982). As actual spawning of round whitefish was not observed, the locations of spawning areas must be inferred by the presence of fishable concentrations of ripe adults in areas of suitable spawning substrate. Consequently, round whitefish are considered to spawn in 5-10 m of water intermittently along most of the shoreline studied, with Raby Head, Bond Head and Thickson Point representing major concentrations.

BIOLOGICAL CHARACTERISTICS

The majority of fish collected during each of the studies were sexually mature and in spawning condition. Almost all round whitefish aged 3 or older, and a portion of the 2+ individuals, were mature (Table 5). Males appeared to mature earlier than most females. The age of maturity in our sample is similar to that reported in Lake Michigan (2 to 3 years, Armstrong et al 1977, Mraz 1964), but earlier than that in Ungava (4 to 6 years, MacKay and Power 1968).

The main spawning activity of round whitefish probably occurred during the first two to three weeks of December, since ripe individuals were still being caught into the second week, and the few spent females collected were all taken in December when water temperatures were 3°C or less. Spawning dates for round whitefish have been reported as the first 3 weeks of December in Newfound Lake, New Hampshire (Normandeau 1969) and November in Aishihik Lake, Yukon (Bryan and Kato 1975). Mraz (1964) reported that spawning was complete by December 13, 1951, in northern Lake Michigan. Cited spawning temperatures ranged from 2°C to 4.5°C (Koelz 1929, Normandeau 1969, Bryan and Kato 1975).

Over the course of these studies the male: female sex ratio favoured females slightly; however, this ratio was extremely variable among years, ranging from 0.45 to 3.73 (Table 6). As the sex ratio may vary over the course of the spawning run, this high variability may be related to annual differences in the contribution of fish from various periods of the spawning run. Mraz (1964) and Normandeau (1969) found spawning run sex ratios to be biased toward males, and Bailey (1963) and MacKay and Power (1968) found males more numerous in younger age groups, but females

more numerous in the older ones.

The age distributions of round whitefish (Table 7) varied among years, but were similar at Pickering and Darlington in 1980, the only year of simultaneous collection. This variability was probably due to differences in year-class strength. The 1977 year-class was relatively strong, which coincides with strong 1977 year-classes of lake whitefish and cisco (*Coregonus artedii*) in other parts of Lake Ontario (Ontario Ministry of Natural Resources, unpublished data).

Calculated total lengths at each annulus are compared in Table 8 for round whitefish populations from the Great Lakes and Ungava. Round whitefish from Lake Ontario had growth rates similar to those from central Lake Michigan (Armstrong et al 1977), but faster than those from Lake Huron (Ontario Hydro unpublished data), northern Lake Michigan (Mraz 1964), Lake Superior (Bailey 1963) and the Koksoak River (MacKay and Power 1968). Although many factors may influence the growth rate of fish, the rank of growth rates in these studies fall on a north-south cline, suggesting an inverse relationship between latitude and growth of round whitefish.

Bailey (1963) reported the presence of Lee's phenomenon (a progressive decrease in calculated length with increasing fish age) in Lake Superior round whitefish, while Armstrong et al (1977) noted increasing calculated lengths with increasing age in round whitefish from Lake Michigan. Back-calculated total lengths of Lake Ontario round whitefish from different year-classes (Table 9) do not indicate the presence of Lee's phenomenon.

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TABLES

Table 1. Number and location of gill nets set during round whitefish studies, Lake Ontario, 1976 to 1981.

YEAR	DATES	AREA	NET LOCATIONS[1]	DEPTHS[2] (m)	PANEL LENGTH[3] (m)	TOTAL NUMBER OF SETS
1976	Nov. 11-Dec. 3	Darlington	8-10, 12	2	30.5	44
1977	Nov. 10-Dec. 6	Darlington	9-14, 16	3	15.3 or 36.6	34
				10	15.3 or 36.6	34
1978	Nov. 15-Dec. 7	Wesleyville	17-22	5	15.3	21
				15	15.3	21
1979	Nov. 22-Dec. 13	Pickering	4-7	3	45.8	7
				10	45.8	9
1980	Nov. 19-Dec. 10	Pickering	1-5	3	15.3	40
			6-7	3	15.3	7
				3	45.8	9
	Nov. 21-Dec. 12	Darlington	8, 9, 12 14-16	3	45.8	15
1981	Nov. 18-Dec. 15	Pickering	7	3	15.3	5
				7	15.3	5

[1] Numbers refer to locations on Table 3.

[2] Depth at which inshore end of net was set.

[3] Nets consist of 8 panels with mesh sizes 3.8 cm to 12.7 cm, in 1.3 cm increments, except in 1976 when one 30.5 m panel of either 8.9 cm or 11.5 cm mesh was set, and in 1977 when nets consisting of 6.4, 8.9 and 11.4 cm mesh or 7.7, 10.2 and 12.8 cm mesh were set.

Table 2. Composition (%) of gill net catches from Lake Ontario during November and December 1976-1981.

SPECIES	AREA: LOCATIONS[1]:	DARLINGTON 9-16			WESLEYVILLE 17-22	PICKERING 1-7			ALL STUDIES
	YEAR:	1976	1977[2]	1980	1978[2]	1979	1980	1981	
White Sucker		31	29	56	47	65	22	5	40
Round Whitefish		13	39	15	14	7	23	86	24
White Perch		2	2	3	1	2	20		6
Rainbow Smelt		1	1	1	16	10	<1	1	5
Alewife			15		4	<1			5
Brown Trout		4	1	4	2	2	12	2	4
Rainbow Trout		4	<1	13	6	1	5	1	3
White Bass		1	5			5	2	1	3
Gizzard Shad		3	2	1	1	1	5		2
Yellow Perch		9	1	3	1	1	3		2
Northern Pike		27		<1	<1	<1	1		2
Carp			<1	3		1	5		1
Lake Trout			2	<1	1	2	1	1	1
Others		6	3	1	8	4	3	1	4
Number of Fish		127	754	305	288	625	582	95	2776

[1] For locations sampled in each year, refer to Table 3.

[2] 3.8 cm and 5.1 cm mesh included.

Table 3. Catch of round whitefish per 22.9 m of gill net (6.4 cm to 12.7 cm mesh) in Lake Ontario during November and December 1976 to 1981.[1]

AREA	NET LOCATION	1976	1977	1978	1979	1980	1981	1976-1981
Pickering	1 Pickering GS 'A'					0.0(732)		0.0(732)
	2 Pickering GS 'B'					0.7(732)		0.7(732)
	3 Duffin's Creek					0.2(732)		0.2(732)
	4 Simcoe Point				0.1(1648)	0.1(732)		0.1(2380)
	5 Richardson Point				0.2(1374)	0.1(732)		0.2(2106)
	6 Whitby West				0.1(1099)	0.3(1650)		0.2(2749)
	7 Thickson Point				0.4(1099)	1.1(1464)	2.1(915)	1.2(3478)
Darlington	8 Darlington Park W	0.1(305)				0.1(824)		0.1(1129)
	9 Darlington Park E	0.2(702)	1.1(366)			0.4(824)		0.6(1892)
	10 Twin Valleys	0.0(122)	0.8(275)					0.4(397)
	11 Raby Head West		1.5(933)					1.5(933)
	12 Raby Head	1.0(214)	1.3(805)			0.5(824)		0.9(1843)
	13 Raby Head East		3.0(677)					3.0(677)
	14 Port Darlington		1.0(1025)			0.0(550)		0.5(1575)
	15 Wilmot Creek					0.2(550)		0.2(550)
	16 Bond Head		3.4(183)			0.4(550)		1.9(733)
Wesleyville	17 Crysler Point			0.2(732)				0.2(732)
	18 Crysler Point			0.2(732)				0.2(732)
	19 Crysler Point			0.2(732)				0.2(732)
	20 Wesleyville			0.3(550)				0.3(550)
	21 Wesleyville			0.1(550)				0.1(550)
	22 Otty Point			0.1(550)				0.1(550)
	All Locations	0.3(1343)	1.7(4264)	0.2(3846)	0.2(5220)	0.3(10896)	2.1(915)	0.6(26484)

[1] Length (m) of gill net (6.4 to 12.7 cm mesh) set is in brackets.

Table 4. Comparison of round whitefish catches per 22.9 m gill net (6.4 to 12.7 cm mesh) according to depth at which the inshore end of the net was set.

AREA[1]	LOCATIONS	DEPTH (m)				
		3	5	7	10	15
Darlington 1977	9-14, 16	2.3[2]			1.2[2]	
Wesleyville 1978	17-22		0.2			0.2
Pickering 1979	4-7	0.3[3]			0.1[3]	
Pickering 1981	7	0.1		4.1		

[1] Only those areas in which nets were set at 2 depths.

[2] $p<0.025$, paired t-test, 33 df.

[3] $p<0.05$, t-test, 14 df.

Table 5. Age and maturity of round whitefish collected from Lake Ontario.

SEX		AGE						
		2+	3+	4+	5+	6+	7+	8+
Male	n	13	36	6	14	10	2	1
	% mature	69	97	83	100	90	100	100
Female	n	12	41	28	18	8	1	
	% mature	17	90	100	100	100	100	

Table 6. Sex ratio of round whitefish caught in Lake Ontario, 1976-1981.

YEAR	LOCATION	MALES		FEMALES		TOTAL NUMBER	MALE/FEMALE RATIO
		NO.	%	NO.	%		
1976	Darlington	5	29	11	71	16	0.45
1977	Darlington	123	42	170	58	293	0.72
1978	Wesleyville	14	42	19	58	33	0.89
1979	Pickering	27	63	16	37	43	1.69
1980	Pickering	63	49	65	51	128	0.97
1980	Darlington	20	43	27	57	47	0.74
1981	Pickering	41	79	11	21	52	3.73
Totals		293	48	319	52	579	0.92

Table 7. Age distribution (%) of round whitefish caught in Lake Ontario, 1976-1981.

LOCATION	YEAR	AGE							
		1+	2+	3+	4+	5+	6+	7+	8+
Darlington (n=86)	1977	0	0	0	21	50	20	8	0
Wesleyville (n=33)	1978	0	6	0	12	48	33	0	0
Pickering (n=43)	1979	0	40	21	0	5	26	7	2
Darlington (n=47)	1980	0	2	51	23	21	2	0	0
Pickering (n=150)	1980	1	8	50	26	13	2	0	0
Pickering (n=52)	1981	0	0	12	38	27	10	13	0

Table 8. Calculated total length (cm) at the end of each year of life of round whitefish from the Great Lakes and Ungava.

LOCATION	YEARS OF LIFE											
	1	2	3	4	5	6	7	8	9	10	11	12
Lake Ontario[1]	13.5	26.0	34.3	39.5	43.2	47.3	49.3	51.3				
Central Lake Michigan (Armstrong et al 1977)	13.9	25.5	34.6	39.6	43.6	46.0	48.1					
Lake Huron[1] (unpublished data)	14.1	23.8	31.3	36.6	40.4	42.6	44.4					
Northern Lake Michigan (Mraz 1964)	11.7	22.9	31.2	36.1	39.9	44.7	47.5	50.0				
Lake Superior: (Bailey 1963)												
Apostle Islands	8.6	15.2	21.3	26.2	30.7	33.8	35.8	38.1	39.9	41.2	43.7	44.0
Isle Royale	11.7	18.3	23.1	27.4	30.7	33.3	35.8	37.9	39.4			
Koksoak River, Ungava[1] (MacKay & Power 1968)	7.0	10.9	15.1	18.7	22.0	25.1	27.9	30.4	32.6	34.5	36.6	38.5

[1] Converted from fork lengths.

Table 9. Scale measurements (in mm) and back-calculated total lengths (in cm) of round whitefish collected from Darlington in 1977 and Pickering in 1980.

AGE (Annulus)		YEAR CLASS						
		1972	1973	1974	1975	1976	1977	1978
1	Scale Radius	0.87	0.87	0.88	0.88	0.84	0.87	0.87
	Total Length	13.5	13.5	13.6	13.6	13.1	13.5	13.5
	n	39	27	11	36	24	73	6
2	Scale Radius	2.06	2.15	2.07	2.20	2.17	2.13	2.18
	Total Length	25.3	26.2	25.4	26.6	26.3	26.0	26.4
	n	39	27	11	36	24	73	6
3	Scale Radius	2.97	3.04	2.98	3.18	3.09	3.15	
	Total Length	33.1	33.8	33.5	35.2	34.1	34.8	
	n	39	27	11	36	24	73	
4	Scale Radius	3.58	3.64	3.68	3.90	3.84		
	Total Length	38.4	38.8	39.2	40.8	40.4		
	n	39	27	9	36	24		
5	Scale Radius	3.98		4.28	4.47			
	Total Length	41.5		43.7	45.0			
	n	39		9	36			
6	Scale Radius			4.76				
	Total Length			47.3				
	n			9				

FIGURE

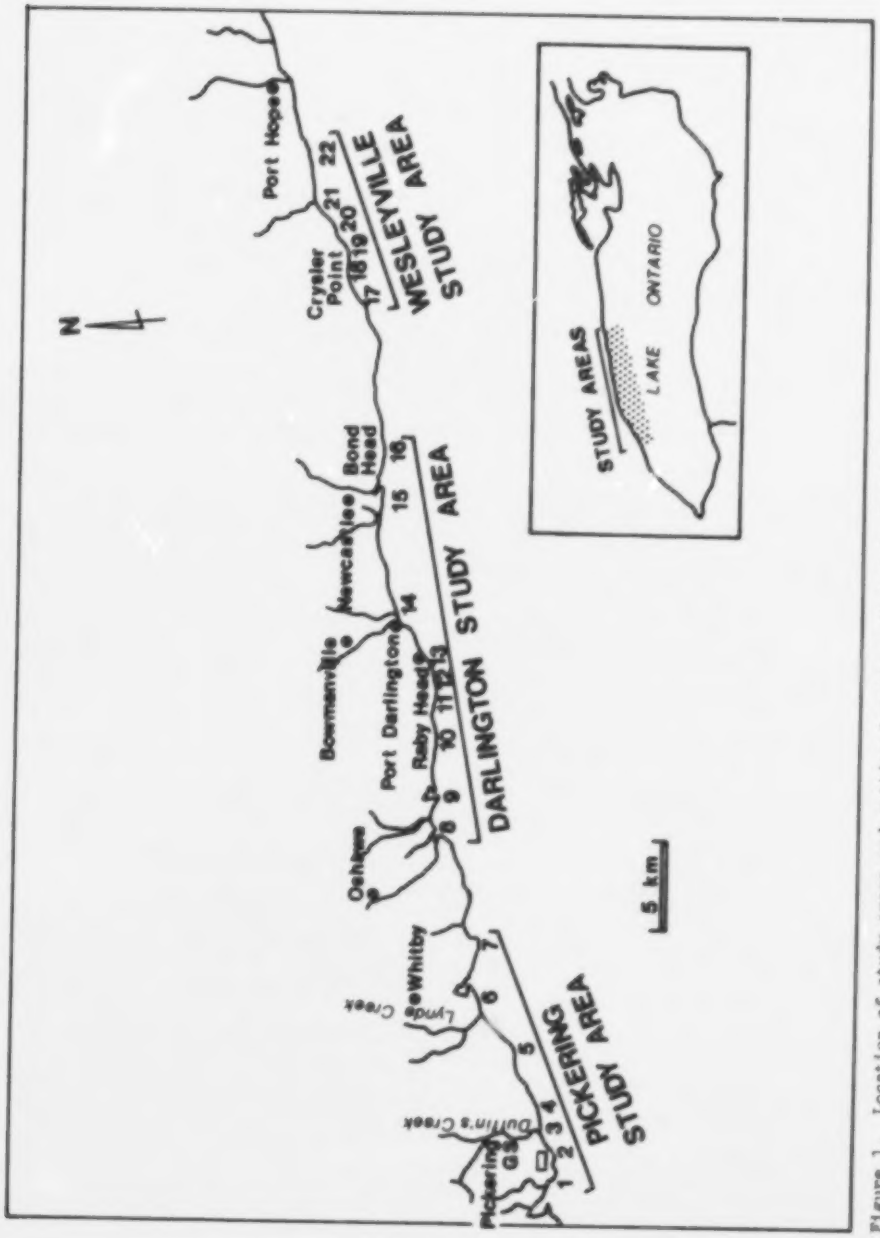

Figure 1. Location of study areas and netting locations listed in Table 3.

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